

Stochastic Analysis of Satellite-Derived Arctic Sea Ice Information

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LONG-TERM GOALS

Long-term goals include the analysis and synthesis of *in-situ* and remotely sensed data for the purpose of understanding sea-ice kinematics, dynamics, and thermodynamics. Particular focus includes the careful consideration of temporal-spatial coupling of specific processes relative to the temporal-spatial sampling and uncertainty of select instruments. Resultant algorithms serve to improve the combination of observations and numerical models especially in the construction of observational test cases, model initialization, and data assimilation. The ever increasing complexity and high volume of both models and data necessitates that observation-derived fields be clear and simple synthesis products that are easy to incorporate into models with careful accounting of the data uncertainties.

OBJECTIVES

We intend to accomplish three main goals:

- 1) provide measures for quality control of sea-ice motion products notably in regard to temporal-spatial variability and error propagation;
- 2) prepare three SAR-derived datasets in the Arctic (SIMI, Sheba, Buoy 2001/2002) for testing the validity of using motion-derived products as direct input to high-resolution models; and
- 3) investigate a stochastic formulation for sea-ice models subject to a plasticity constraint for scales of 10-300km.

APPROACH

The approach is to construct Lagrangian time series of coincident buoy and SAR-derived motion products from the SIMI, Sheba, and Beaufort 2001/2002 ONR field programs. Using a statistical

approach, the local drift and deformation can be computed over these time frames to assess the impact of temporal and spatial scale on the determination of deformation values. Development of practical fields such as time series of continuous and discontinuous sea-ice motion (i.e., high-resolution lead-resolving fields) will serve as a valuable tool for understanding the evolution of aggregate-scale processes. Once constructed, the time series will be used for analysis by this research group and eventually made available to the modeling community for case studies and data assimilation.

S. Lyn McNutt and her graduate student at UAF are in charge of isolating the satellite scenes coincident with the buoys from the three field programs. Cathleen Geiger is responsible for the analysis. A Ph.D. student under Cathleen Geiger will assist beginning in the second year under an ONR acceleration grant (start date Oct 1, 2002) with the motion vector rendering of the SAR images using methods developed by Thomas, Geiger, and Kambhamettu under NSF grant OPP9818645.

WORK COMPLETED

Five major tasks have been accomplished in this first year's effort.

- 1) The isolation of about 200 RADARSAT scenes from Sheba and 400 RADARSAT scenes from the Beaufort buoy project 2001/2002 via McNutt's group at ASF. SIMI buoy and ERS-1 data still being retrieved from archives.
- 2) Buoy trajectory data from two experiments delivered to the University of Delaware (UD) for analysis by Geiger.
- 3) A DAR plan has been submitted by Geiger and approved (as of September 19, 2002) for the reprocessing of the needed SAR images.
- 4) Animations and cataloguing of coincident time windows between buoys and SAR image pairs have been constructed using software developed by Geiger. This is to ensure proper identification of image pairs prior to the lengthy motion-rendering process.
- 5) A multi-scalar motion tracking scheme has been developed by Mani Thomas under the guidance of C.A. Geiger, and C. Kambhamettu under NSF funding OPP9818645. The algorithm is in the process of being automated with documentation (a technical report and peer-reviewed publication) in early preparation.

RESULTS

Using a phase correlation method to render sea-ice motion from ERS-1 test images in the Weddell Sea, we can reconstruct velocity fields of sea-ice at very high resolution (max resolution 4x4 pixels at 100m resolution). We take advantage of one fundamental limitation of correlation, namely its inability to resolve regions of discontinuous motion, to produce fields of continuous and discontinuous motion and therefore the location of shear zones and/or leads (e.g., Figure 1).

IMPACT/APPLICATIONS

A scalar correlation coefficient map not only provides a statistical measure of how well a motion-rendering algorithm is behaving in each area of a grid, it also serves as a delineation field between

continuous and discontinuous regions of ice motion and therefore a guide to shear zones and/or leads. This combination of fields can be used in numerical models to help initialize the model field, test against model output to improve model physics, or serve as observations in data assimilation fields. We are hoping to analyze these combinations further in the form of sequential images to look at a satellite revisit time sampling rate and its ability to resolve such features along a Lagrangian trajectory.

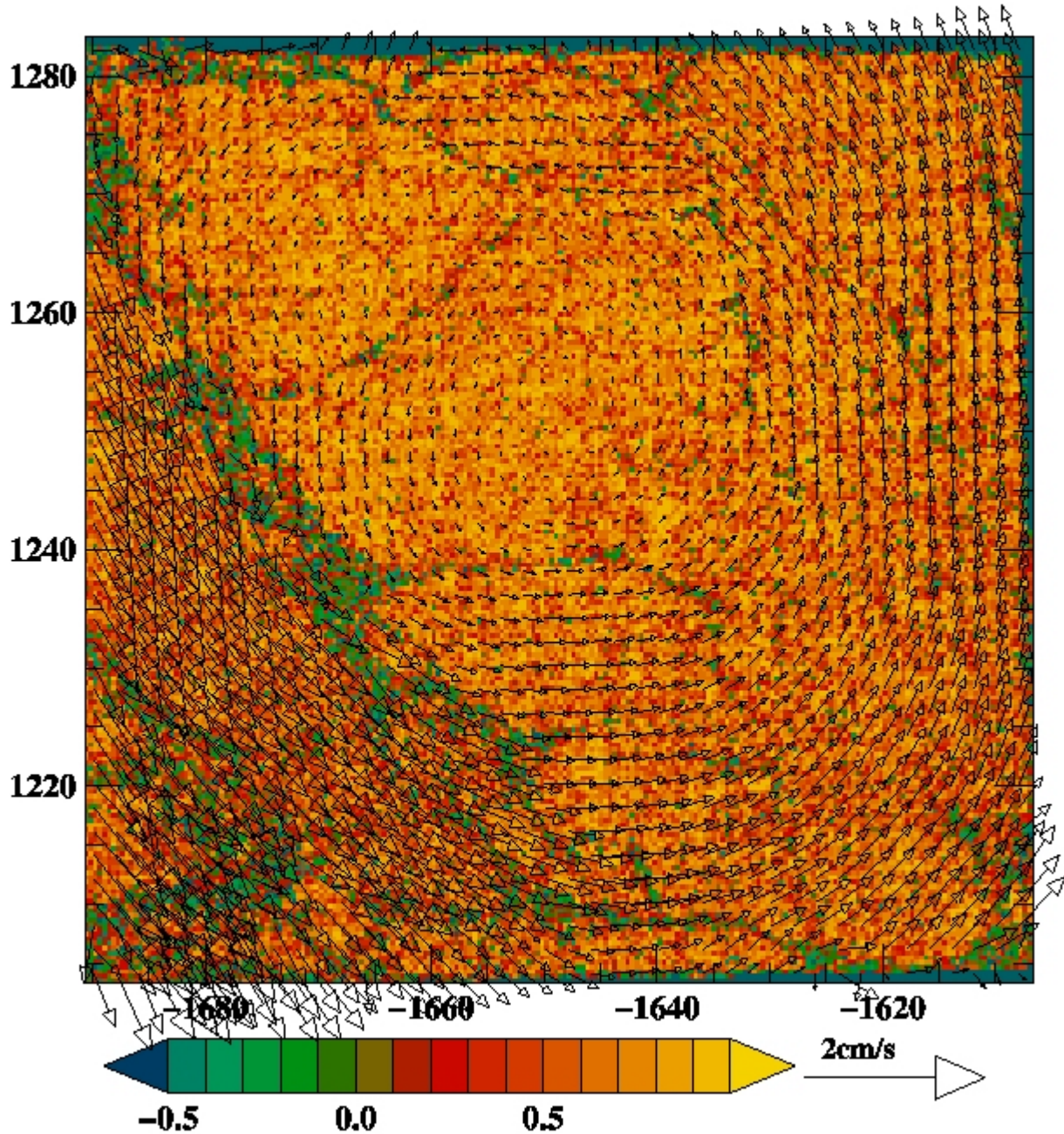


Figure 1: SAR-derived differential motion vectors and associated correlation coefficient (colored boxes). Motion resolved at a scale of 400m with every 5th vector shown. The correlation is lowest in regions of discontinuous ice motion.

TRANSITIONS

The project is less than 9 months underway. However, the preliminary applications of the methods were found of enough interest during an interview process that Geiger has been offered and accepted a job at CRREL beginning January 2003.

RELATED PROJECTS

NSF9818645: Investigation of tidal aliasing and climate scale processes in sea ice and their influence on oceanic-atmospheric heat/mass/momentum balances using stochastic methods, satellite-derived products, and *in-situ* buoy arrays. 1998-2001 with no-cost extension to September 2002. Analysis using coincident buoy and SAR-derived motion products to look at the temporal-spatial coupling of sea-ice processes in the western Weddell Sea. Two relevant publications listed in references.

REFERENCES

Geiger, C.A., and M. Drinkwater, Consideration of tidal motion and other high frequency forcing in the western Weddell Sea: SAR and buoy comparison of sea ice from ISW 1992, submitted to *Journal of Geophysical Research*, 2002.

Geiger, C.A., and M.R. Drinkwater, Impact of temporal-spatio resolution on sea-ice drift and deformation, IUTAM Symposium on *Scaling Laws in Ice Mechanics and Ice Dynamics*, (eds.) J.P. Dempsey and H.H. Shen, Kluwer Academic Publishers, Netherlands, 407-416, 2001.